Design Contest 2013

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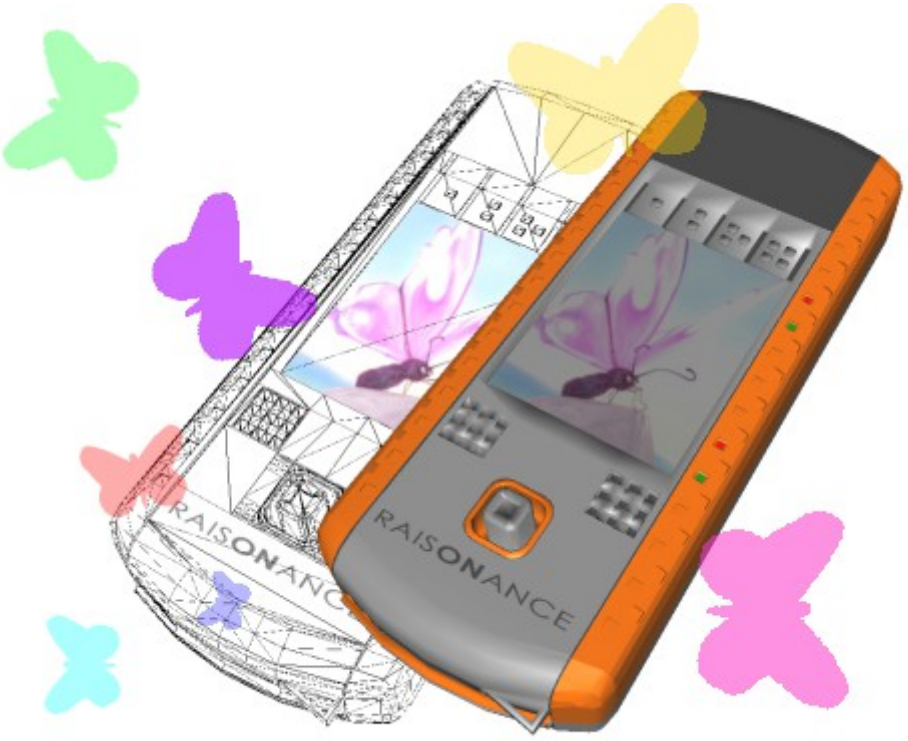


Design Contest 2013 Version

ZP VIDEO PLAYER

User Manual

1. Introduction

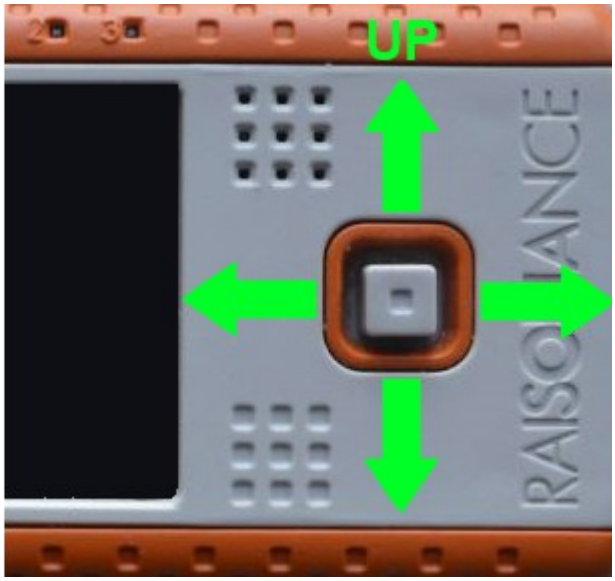
ZP Video Player is intended to play video files on a KEOLABS STM32-PRIMER with a STM32F429 target board. Supported video files must be encoded as a standard IBM / Microsoft RIFF container for AVI files with a MJPEG compression with a mono or stereo sound track in a PCM format with a bit depth and sampling frequencies in full range of used STA529 codec. It would be practical to use 8 or 16 bits per channel and the sampling frequency from 8KHz to 48KHz. If the sound stream exceeds these limits the audio data will be ignored. An AVI file without any sound track will be played as well. AVI files with more than two streams and/or subtitles are not supported.

A video resolution can be up to 320x240 pixels. The video stream with a bigger resolution will not play due to poor performance (i.e. it is software limited). The video stream with a smaller resolution will be resized proportionally to fit the 320x240 pixels area.

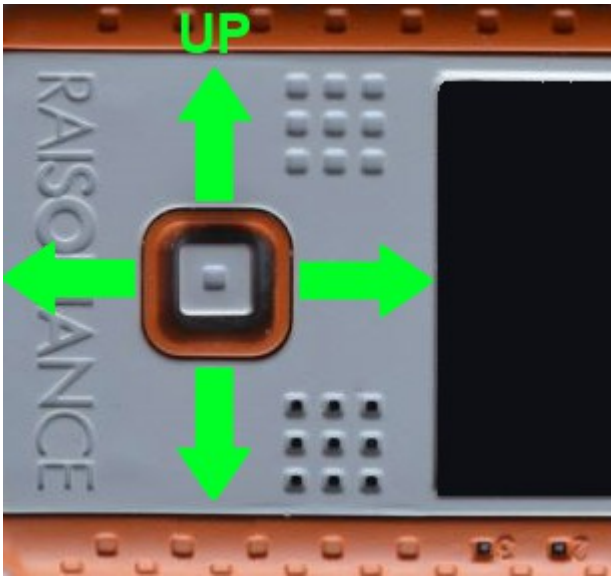
As an application demo the audio WAVE format player is added to the program in build 0250.

The current version supports the SD cards (class 10 is recommended) with a FAT32 file system and a 8.3 file name convention only as a media. It can be extended to support USB sticks and long file names as well.

The current version supports STM32-PRIMER landscape orientation only when the joystick is placed at the right as seen in Picture 1.1 or when the joystick is placed at the left as seen in Picture 1.2. You can see below what “Up” and other directions for the joystick mean in both cases.



Picture 1.1
In terms of the program this is an ORIENTATION_270 mode



Picture 1.2
In terms of the program this is an ORIENTATION_90 mode

The current orientation is constantly updated by MEMS accelerometer data.

The “hardwared” touchscreen buttons are numbered in accordance with the number of dots on their surfaces, from 1 to 4, and they are always irrelevant to orientation.

Picture 1.3
Touchscreen buttons

2. User interface

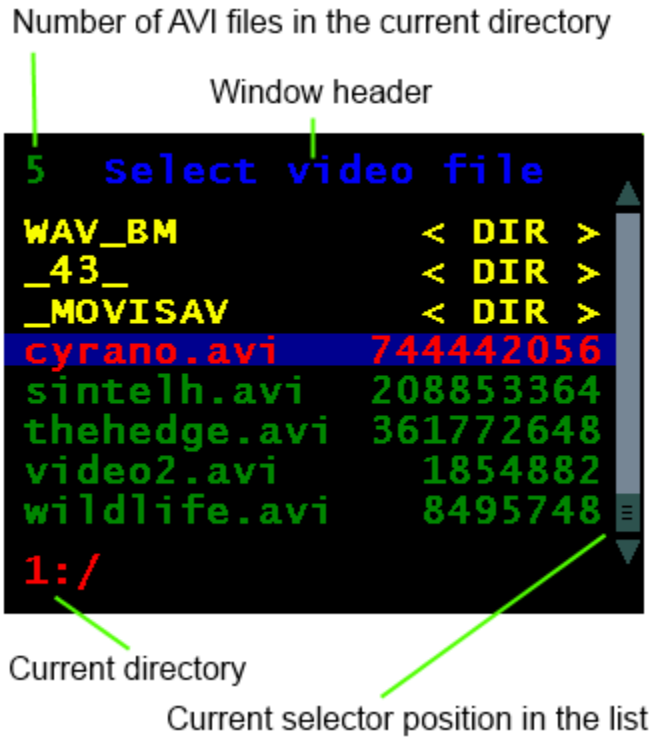
From the moment of powering up the program tries to check if the backup SRAM (in RTC domain) contains the system data (f.e. touchscreen coefficients, desired volume etc) or is reset. In case of reset the program is starting the touchscreen calibration. You have to hit the white cross four times (once in a each corner). You have three attempts to complete calibration. If calibration failed the program loads default data. You can try to recalibrate touchscreen later at any time.

The touch screen calibration is allowed to run for both right-hand (ORIENTATION_270) and left-hand (ORIENTATION_90) and result will be the same. In case of success you'll see the dark slate gray window with a text “Calibration OK.”.

Then the program tries to read a SD card root directory. If an SD card has not been inserted or cannot be accessed the pop-up window will appear. There are two choices, “Quit” and “Retry”.

You can navigate the options by using the joystick and select an option by pressing the joystick button. Or you can just use the touchscreen.

After a valid SD card has been detected the program reads and displays the root directory as seen below.



Picture 2.1
File selector in action

The directory items are displayed in yellow, AVI files in green, all others in dark slate gray color. The file size in bytes will be displayed to the right of file items. The current directory string is below the list

in red.

You can navigate in the current directory by pulling the joystick up or down. To change the current directory you have to select desired directory and then press the joystick button. To return to the parent directory you need to pull the joystick right. The previous position in the parent directory is then restored.

To play an AVI file select it and press the joystick button. Pressing the button on any other file has no effect (you can easily add the support for the file types you need).

The number of AVI files in the current directory does not mean they all can be played by ZP Video Player. This means that this number of files just have an AVI extension.

Only 8.3 convention compliant files and directories are displayed in the list, all other files are ignored. The files and directories displayed are sorted strictly alphabetically. The number of displayed items is limited to up to 64 for directories and up to 768 for files. You can change these limits if you want to.
Pulling the joystick left leads to a "Quit" dialog popping up as depicted in Picture 2.2:

Picture 2.2

The "Quit" window is modal. You can navigate by pulling joystick left or right and select option with pressing the joystick button. Or use the touch interface directly. The pressing time for the joystick button must be short enough due to the same button is used for switching the STM32-PRIMER on.

"Quit" means the shutdown while "Cancel" means closing the "Quit" dialog.

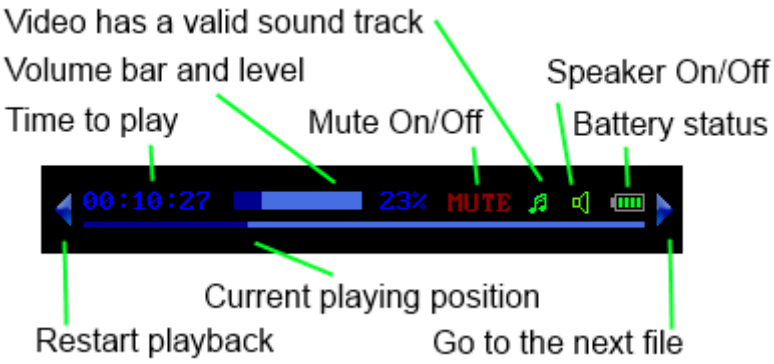
While File selector is running you can start the touchscreen calibration by pressing button2 (see Pic.1.3).

3. Playing video

If the joystick button is pressed on an AVI file the playing starts. If the selected file meets the p.1.1 requirements, you will be able to see the video. In case it does not the program skips the current file and will try to play the next AVI file in the same directory.

Below is a screenshot of a “Cyrano de Bergerac” movie (1950, public domain), with native resolution 160x120 pixels extended to 320x240 pixels automatically.

Picture 3.1



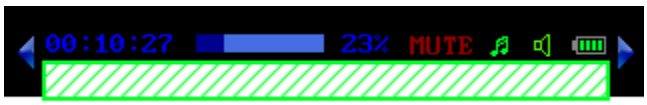
Picture 3.2

You can control playback by the toolbar as seen in Picture 3.2 by using the touchscreen, some operations can be carried out by using the joystick and “hardwared” touchscreen buttons 1..4.

If you tap the “restart playback” button the same file starts playing from the beginning.

If you tap the “go to the next file” button the program will start playing the next AVI file in the current directory or the same file if there is a single AVI file. The same effect is achieved by pulling the joystick right.

If you tap the file progress bar or any area below it as depicted in Picture 3.3 the file playing will continue from the new position proportional to horizontal touch distance.



Picture 3.3

Tapping the volume bar changes the volume corresponding to the horizontal touch distance from the start of the bar. The volume in percentage is displayed to the right of the volume bar. Alternatively, you can change the volume by pulling the joystick up or down.

Touching the “MUTE” will switch a mute mode On or Off. If mute is on you will see a red string “MUTE” otherwise nothing is displayed.

You can switch off speaker only and use the headphones by tapping the “Speaker On/Off” icon. When the speaker is off, the icon becomes red. The speaker can be switched On or Off by pressing the “hardwared” button 2.

The icon “Video has a valid sound track” becomes green if ZP Video Player can play sound for that particular file. If there is no sound track or it is in an unsupported format the icon becomes red.

“Time to play” shows the time left till the end of the current file. If you have navigated the file playback position the time counter may become incorrect up to several seconds.

“The battery status” indicates the status of internal battery. If you use a USB connector to power there are three possible states. If the battery is full you will see the icon as depicted above in Picture 3.3. If the battery is charging the number of green bars inside the battery icon will change periodically. If the battery is switched off the icon will be changed to this:

Picture 3.4

Due to capacitor in parallel with battery it may take up to 2 minutes to detect the lack of battery if you switch the battery off while powering from the USB.

If the battery is the main power source the number of bars inside the battery icon will be gradually decreased and the icon will become red. This means you have to charge the battery as soon as possible. The fully charged battery can give up to 80 minutes of playback time with sound. The current program version does not contain any power saving options. The LCD backlight management is the simplest way to prolong the playback time on battery power.

The “hardwared” touch button 3 switches the visibility of the tool bar.

The “hardwared” touch button 4 returns to the file system navigation as described at p.2.

You can pause playback at any time by pressing the joystick button or tapping the center of the touchscreen. The next instance of tapping or pressing breaks the pause.

While the playback is paused you can save the current frame (the whole screen) as a bmp file. These screen shots are placed in a “VP_SAVED” directory under a “VPxxxxxx.bmp” name. The xxxxxx numbers are selected from 0. If the STM32-PRIMER is switched off the number is remembered in the backup memory (RTC domain). If the power and the battery are both switched off then this number is reset. If you want to keep previous screenshots you must save them on another media.

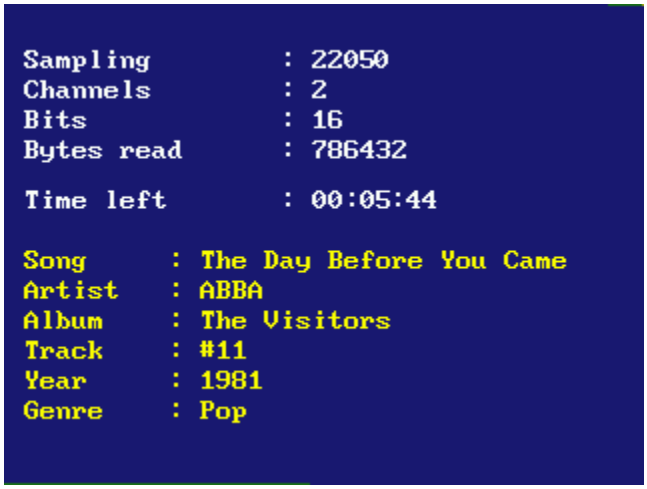
And if you pull the joystick left you will enter the “Quit” mode as described at p.2 and in Picture 2.2.

4. Playing audio

This audio player is a demo application with limited functionality.

If the joystick button is pressed on an WAVE file (i.e. *.WAV) the audio playing starts. Sampling frequency can be up to 96 KHz. WAVE file must be in a mono or stereo format.

The audio player displays the additional content information if it is present as depicted below in yellow.



Picture 4.1
Audio player

Generally the old WAVE files do not contain INFO chunks but if they were converted to WAV from other audio type some converters may add this information.

This version does not contain touch interface for audio playback and has a simplified control. The only controls are volume (move joystick up/down) and return to FileSelector (move joystick to right).

5. ZP Video Player performance

To get the best result you must know the JPEG decoder limits. It is a main component to achieve good performance. It can produce up to 0.8 Megapixel per second with a 168MHz MCU. It is a little bit better than Segger EmWin does and quite exactly correlates with a EmWin 5.22 UM03001 Image Performance Benchmark results (p.1083). Mentioned 200MHz ARM922T CPU Sharp LH7A404 running at 200MHz and with 15 bpp display color depth can produce up to 0.6 Megapixel per second in JPEG decoding. STM32F429I with 16 bpp and resolution 320x240 = 76800 pixels performs the same.

Of course, a frame rate below 8 FPS is too small to play video smoothly. There are several ways to improve overall performance (besides the program improvement).

The simplest way is to overclock MCU. STM32F429x can be overclocked much more easily than the previous STM32F41xx family. The frequency of over 180MHz leads to warranty loss and is not recommended. But for your personal home application you can overclock STM32F429I, for example, to 216MHz or more. This gives more than 1 Megapixel per second in JPEG decoding.

If the source file has a different aspect ratio than 4:3, for example 16:9, then we have only 2/3 pixels to decode compared to full screen 4:3. In this case we will achieve a 30% performance gain.

We can use a smaller source resolution, for example, 160x120 pixels. The decoding time and software extension will perform up to 20 FPS in this case.

The sound quality does not affect the video performance dramatically due to we don't have to decode audio stream, only fast copying and DMA transfer to codec are used. The sound quality affect the source file size only but overall stream bitrate is far below the critical value for the STM32F429I SD/USB/file subsystem.

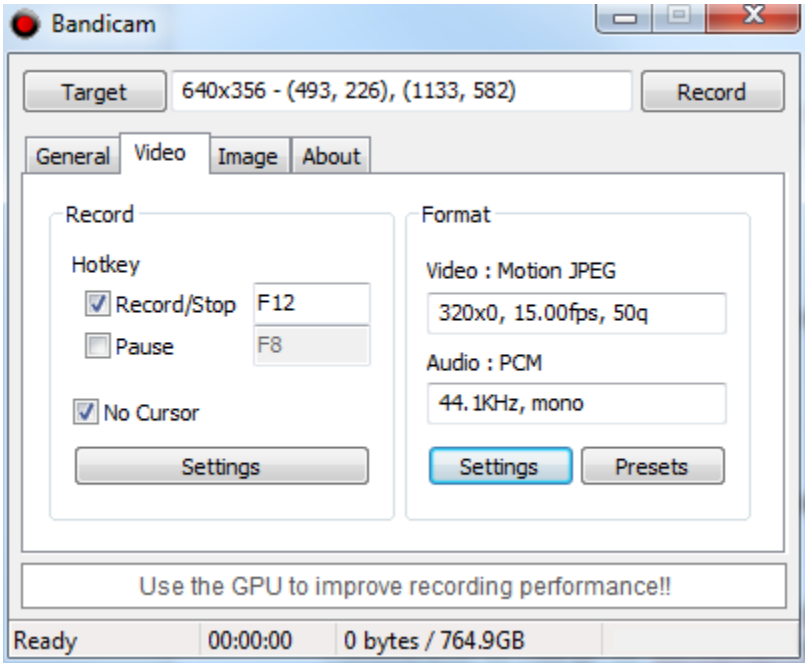
So as a general rule you cannot play 4:3 320x240 videos faster than 13 FPS. If you convert into this format with 25 FPS you will probably get the distorted sound. And in any case you do not get the desired FPS. The value of 12 will be very reasonable. If you use a smaller resolution (for example 160x120 extended to 320x240) your average FPS can be over 18. At least 15 FPS playback with a 22050 Hz 16bit stereo audio will run without any skipped video frames.

If you have a STM32F429-DISCO board you can compare the video playback on this board to the playback on the STM32-PRIMER + STM32F429 (by ZP Video Player). Just rename both “video1.mjpg” and “video2.mjpg” files supplied with STM32F429I-Discovery_FW_V1.0.1 firmware to “video1.avi” and “video2.avi” and copy them to SD card for the STM32-PRIMER. Both files are encoded at a 15 FPS frame rate with a 320x240 resolution. You'll see that EmWin does not provide the time management and just plays all frames one by one. The playback time is twice as needed. This means the performance of about 7.5 FPS at 168MHz, i.e. you have to skip a half of frames to keep the correct play time. The performance of ZP Video Player at the same frequency exceeds 10 FPS and less than 33% of frames are skipped. At 216MHz ZP Video Player performs 13 FPS and only 13% of frames are skipped to keep the right play time.

6. How to create AVI files for the ZP Video Player

There are many programs that can capture/convert video content with a different format to the AVI format with a MJPEG compression and PCM sound.

One of them is Bandicam video converter from Bandisoft Software http://www.bandicam.com/

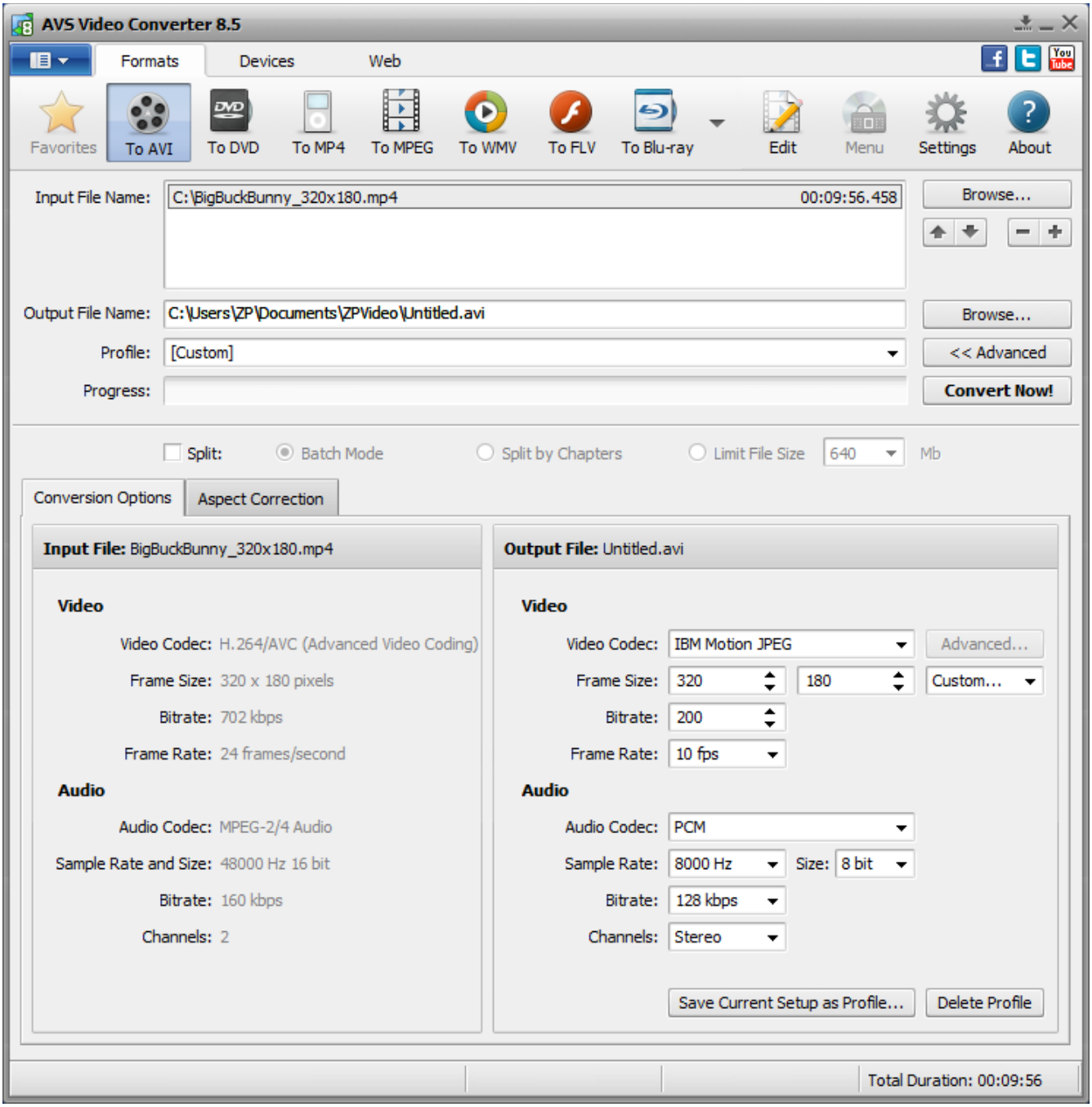


Picture 6.1
Bandicam video converter

Another one is the AVS Video Converter and AVS Video Editor from One Media Technologies Ltd., http://www.avs4you.com/. AVS software bundle includes an Audio editor that can add an INFO tag to the WAVE audio format.

You can try these programs for free. The only difference from the paid version is that the nag screen will appear from time to time.

Why do you need both Converter and Editor? Well, you can do with Converter only. It has a much simpler interface, see Picture 6.2.



Picture 6.2
AVS Video Converter

But the Editor can mange the sound level. Unfortunately Converter does not. This may lead to the very audible distortions in the converted files. For example, Blender Foundation (with the other companies) Open Movies (well known Big Buck Bunny and others) should be converted with an audio level -6..7 dB. Some other video does not require audio level changing or normalization. So the Video Editor is more preferable and can do a lot of other useful things. You can try yourself.

Of course there must be a lot of other programs and free tools available for such job.

You can download some of converted media files for the ZP Video Player by clicking the links below.

Open Movie cartoon projects covered by Creative Commons Attribution 3.0 license. These movies can be freely viewed, copied and distributed:

"Big Buck Bunny", ((c) Blender Foundation 2008).
320x176 pixels, 15fps, 16 bit 22050Hz stereo. Zip size is 201MB.
http://www.zaurosoft.com/ZP_VIDEO/OpenMovie/bigbunny.zip

"Sintel", ((c) Blender Foundation 2010).
320x136 pixels, 12fps, 16 bit 22050Hz stereo. Zip size is 176MB.
http://www.zaurosoft.com/ZP_VIDEO/OpenMovie/sintel.zip

"Elephant Dreams", ((c) Blender Foundation 2006).
320x180 pixels, 15fps, 16 bit 22050Hz stereo. Zip size is 164MB.
http://www.zaurosoft.com/ZP_VIDEO/OpenMovie/elephant.zip

"Tears of Steel", ((c) Blender Foundation 2012).
160x120 pixels, 15fps, 16 bit 44100Hz stereo. Zip size is 176MB.
http://www.zaurosoft.com/ZP_VIDEO/OpenMovie/tears.zip

Public Domain movies:

"Cyrano de Bergerac", 1950.
160x120 pixels, 15fps, 16 bit 22050Hz mono. Zip size is 583MB.
http://www.zaurosoft.com/ZP_VIDEO/PublicDomain/cyrano.zip

"The Boy in the Plastic Bubble", 1976.
160x120 pixels, 15fps, 16 bit 22050Hz stereo. Zip size is 835MB.
http://www.zaurosoft.com/ZP_VIDEO/PublicDomain/theboyin.zip

All these files can be played on a PC with a proper codec most players have by default.

7. Afterwords

ZP Video Player is a Design Contest 2013 Product. This means it was created in a competition fever and under time pressure. So a lot of things are skipped or implemented quite badly. But at least with ZP Video Player you can have a little bit more fun with your STM32-PRIMER.

Program is developed by ZP, zp@zaurosoft.com
Design Contest 2013/2014 version. Build 0252.